Accuracy of Animal Borne GPS Receivers in a Post Selective Availability Era

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Introduction

The goal of this study was to evaluate the performance of animal borne GPS platforms in typical habitat situations after Selective Availability (SA) was turned off on May 1, 2000. This information is an unpublished poster presentation displayed during the 62nd Midwest Fish and Wildlife Conference, Minneapolis, Minnesota, USA, 3-6 December 2000.

Methods

•Three test sites were chosen with cover types believed likely to attenuate GPS signals and where multipath propagation was also likely.

• GPS collars built for animal location application were programmed to take and store a location once each hour.

•The units were placed into three groups. One group had two units while each of the other two groups had three units. Each group occupied a site for approximately one week and was then rotated to the next site; thus all sites were continuously occupied.

•Data were collected from June through September 2000. Data were offloaded after each site change.

•GPS receiver boards from three different manufacturers were tested. All units used active microstrip patch antennas.

•The location of each test site was determined by using survey grade GPS receivers and differential post-processing with a local control point as the reference. To ease calculations data were converted from latitude, longitude to UTM coordinates. Typical forest stand parameters were also measured at each site.

Red Pine Stand

- **Site Description:** Row planted red pines. Rows were planted about 3 meters apart. Every other two rows has been removed.
- **Ground Cover:** Small birch
- **Canopy Closure:** 50%
- **Canopy Height:** 21 m
- **Tree Height Average:** 21 m
- **Tree Height Range:** 2 – 24 m
- **Tree Diameter Average:** 18 cm
- **Tree Diameter Range**
  - **Birch:** 1.9 cm – 2.5 cm
  - **Red Pine:** 7 cm – 27 cm
- **Basal Area Per Hectare:** 23.5 m^2
- **Trees Per Hectare:** 2,500

Sumac Stand

- **Site Description:** A naturally occurring sumac stand surrounded by aspen and oaks.
- **Ground Cover:** Golden rod less than 0.8 m tall
- **Canopy Closure:** 70%
- **Canopy Height:** 7.5 m
- **Tree Height Average:** 7 m
- **Tree Height Range:** 1 - 18 m
- **Tree Diameter Average:** 4.3 cm
- **Tree Diameter Range:** 1.6 cm – 15 cm
- **Basal Area Per Hectare:** 19 m^2
- **Trees Per Hectare:** 15,300
- **Sumac Stand Only**

Tree Height Average: 7.6 m

Tree Diameter Range: 1.9 cm – 2.5 cm

Trees Per Hectare: 30,000

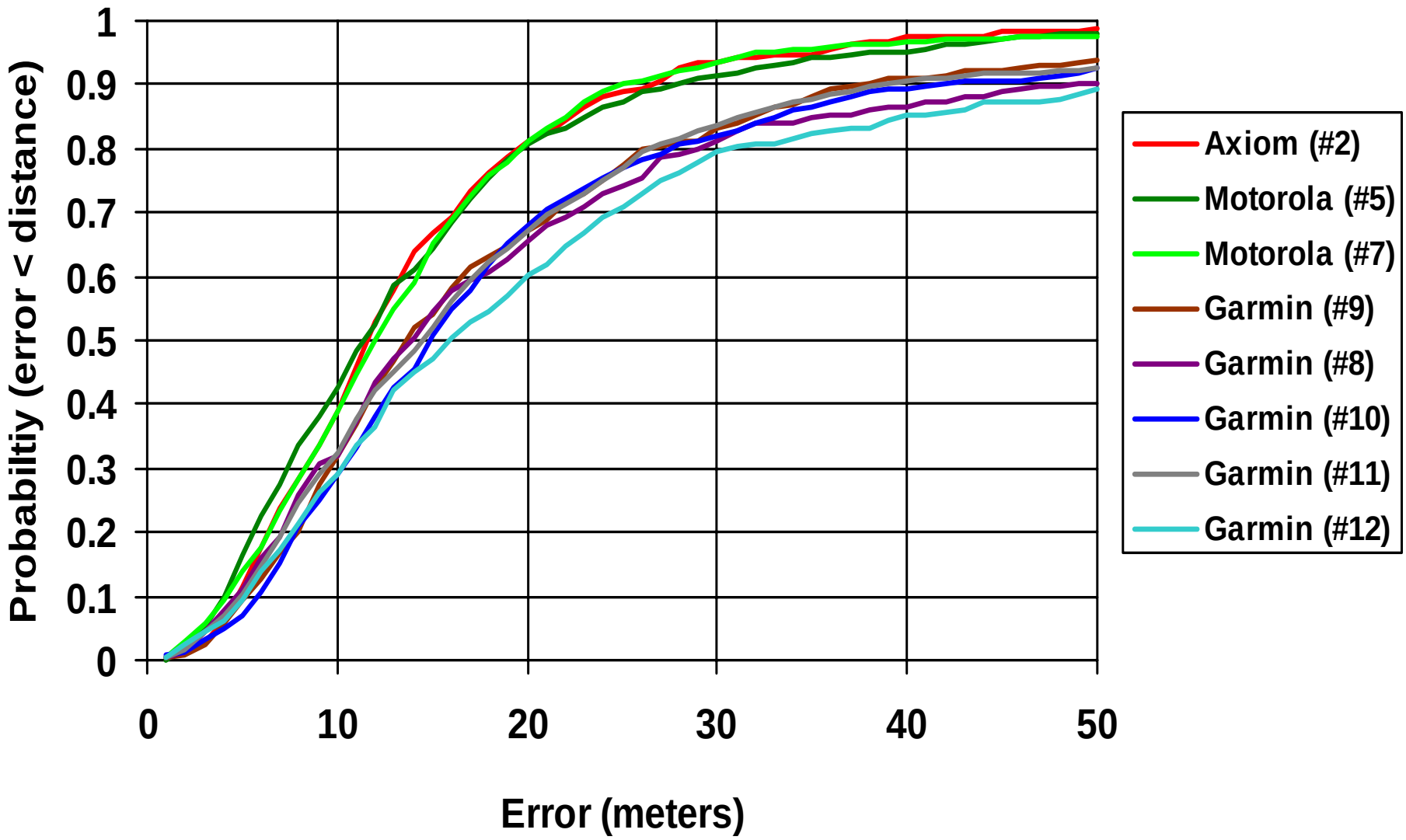
Tree Diameter Average: 3 cm

Basal Area Per Hectare: 24 m^2

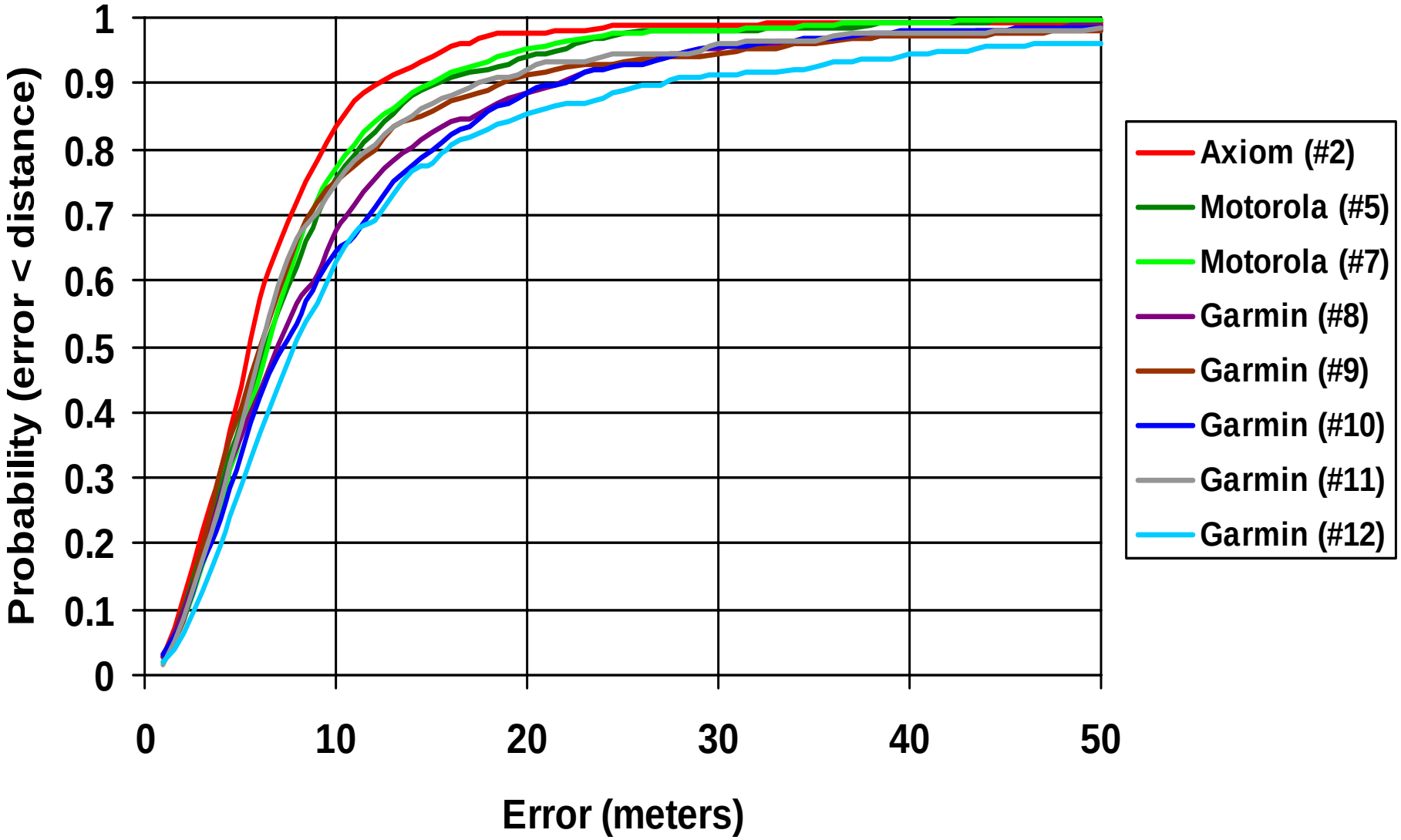
Lowland Deciduous

- **Site Description:** Naturally occurring lowland deciduous consisting primarily of ash.
- **Ground Cover:** Forbs less than 0.5 m tall
- **Canopy Closure:** 80%
- **Canopy Height:** 17 m
- **Tree Height Average:** 12 m
- **Tree Height Range:** 2 – 25 m
- **Tree Diameter Average:** 14 cm
- **Tree Diameter Range:** 2 cm – 75 cm
- **Basal Area Per Hectare:** 52 m^2
- **Trees Per Hectare:** 3,200

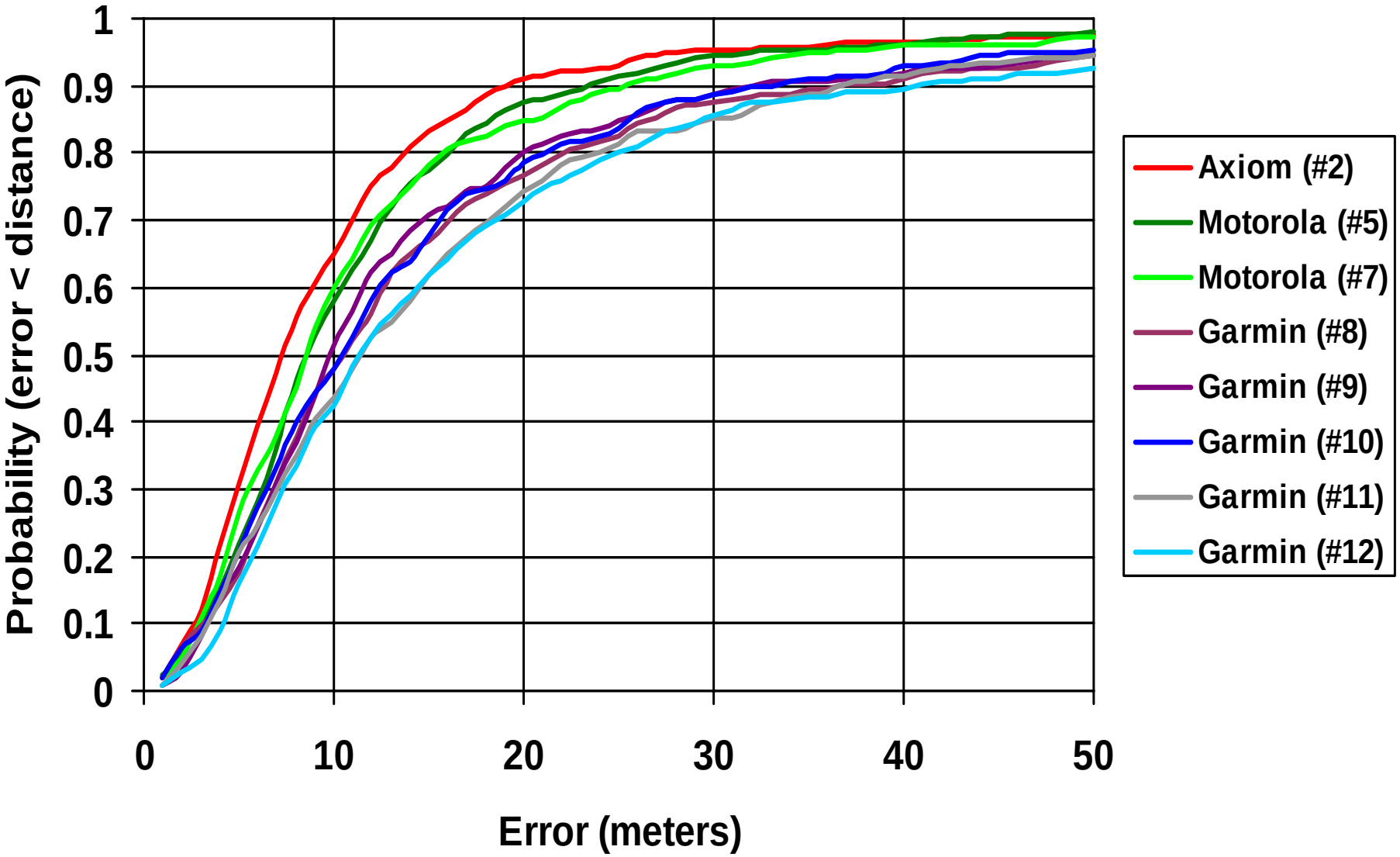
Distance Error Probability (Red Pine Stand)

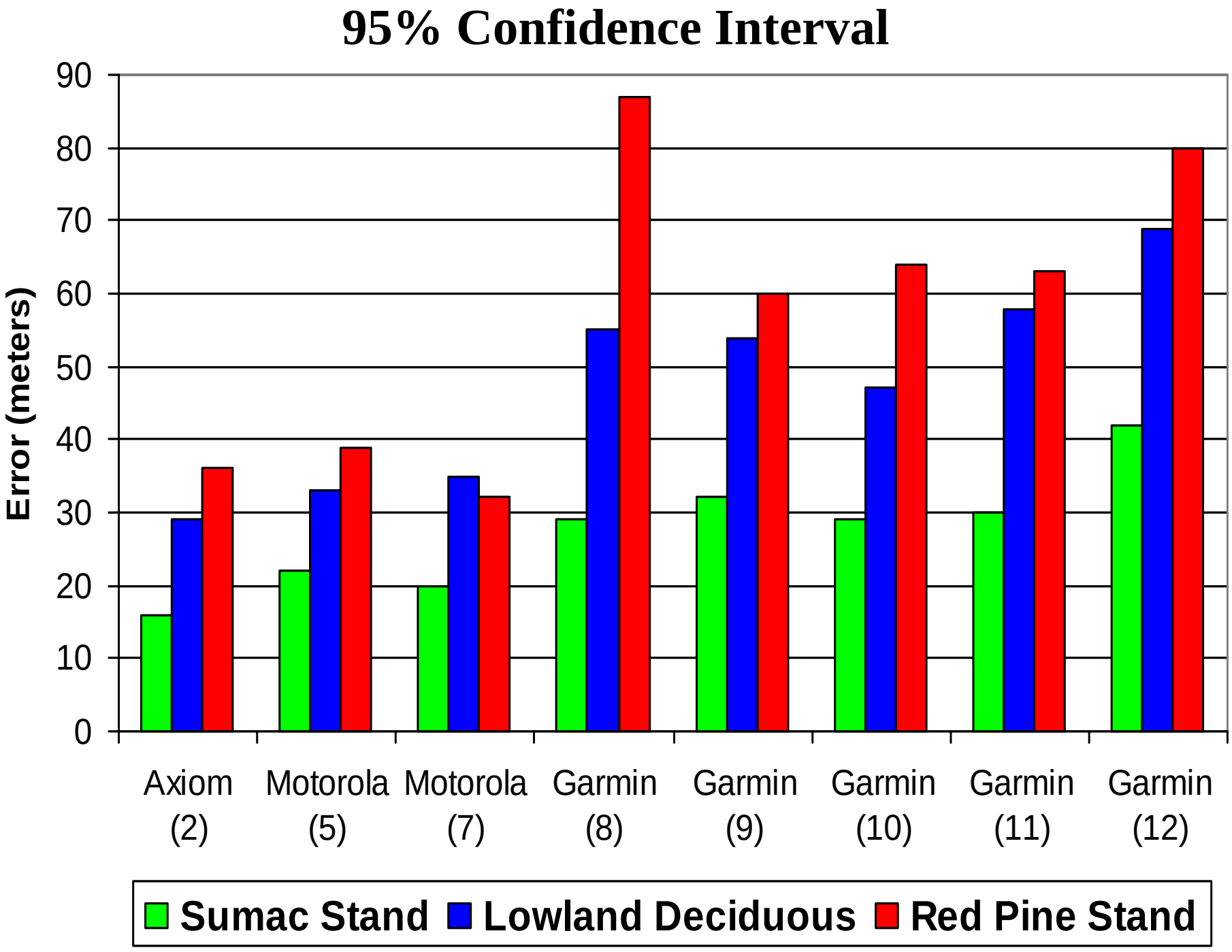


Distance Error Probability (Sumac Stand)

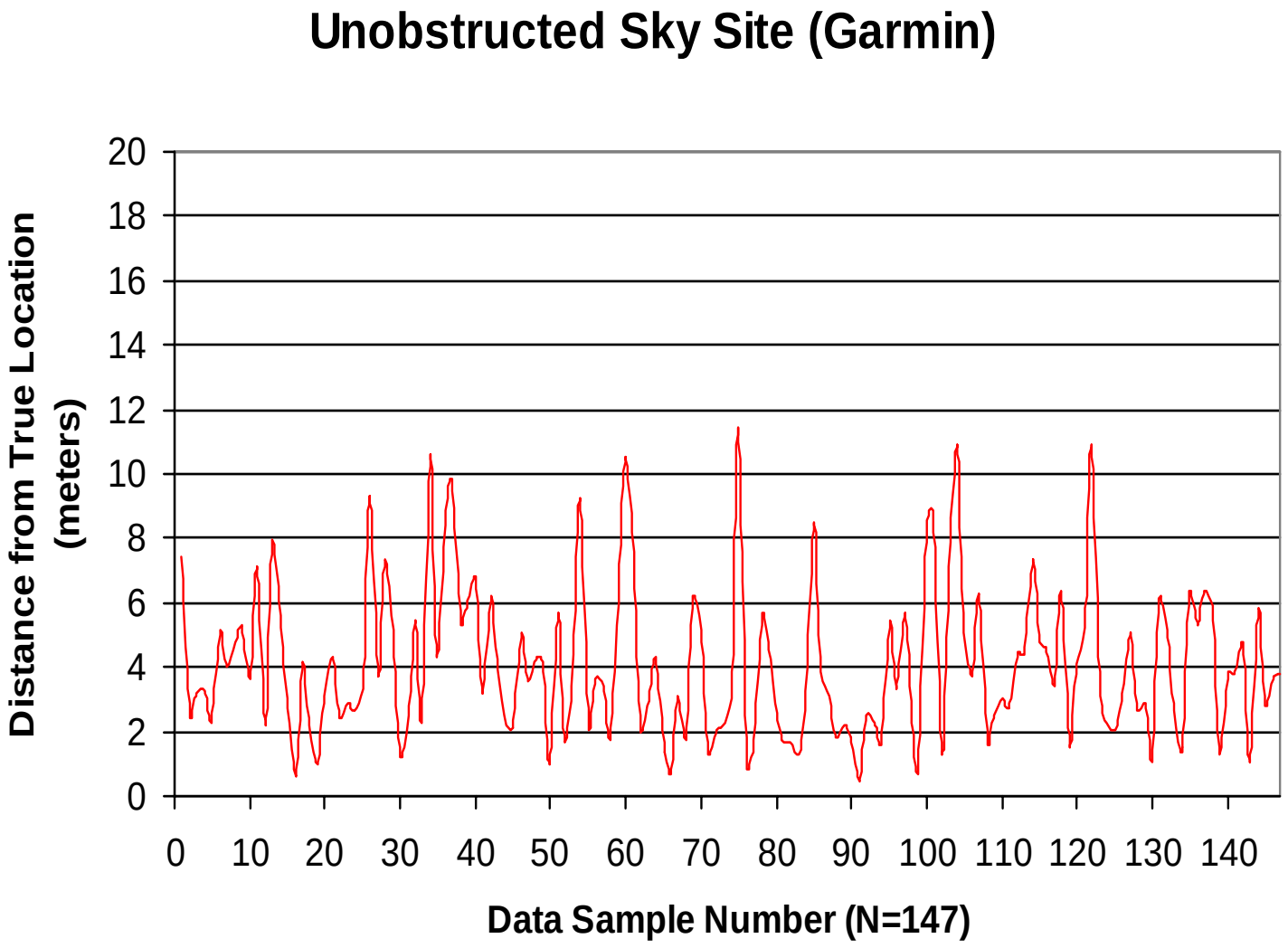


Distance Error Probability (Lowland Deciduous)



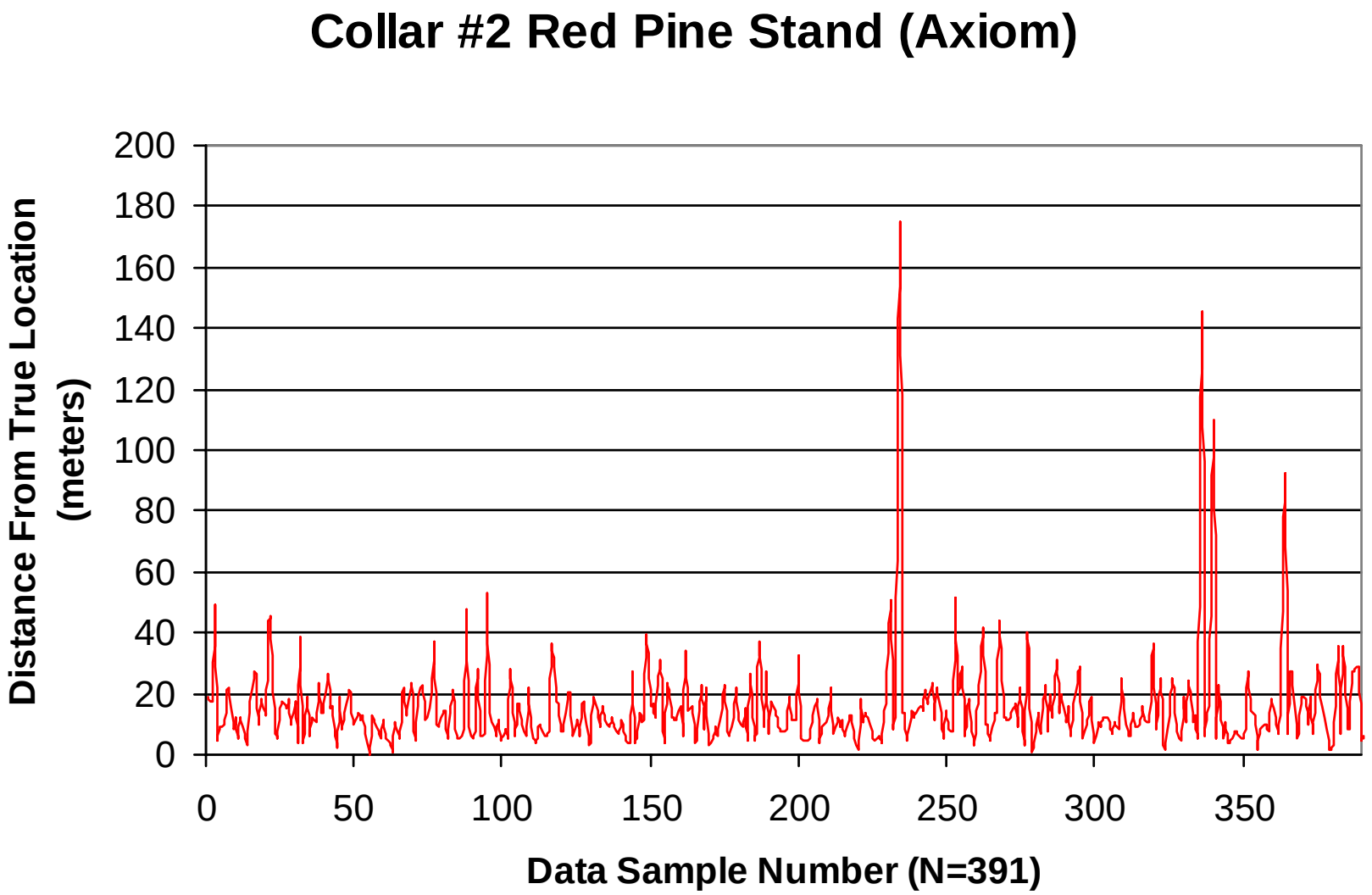

95% Confidence Interval
Error (meters)
90
80
70
60
50
40
30
20
10
0
Axiom (2)
Motorola (5)
Motorola (7)
Garmin (8)
Garmin (9)
Garmin (10)
Garmin (11)
Garmin (12)
Sumac Stand
Lowland Deciduous
Red Pine Stand

Error Excursions

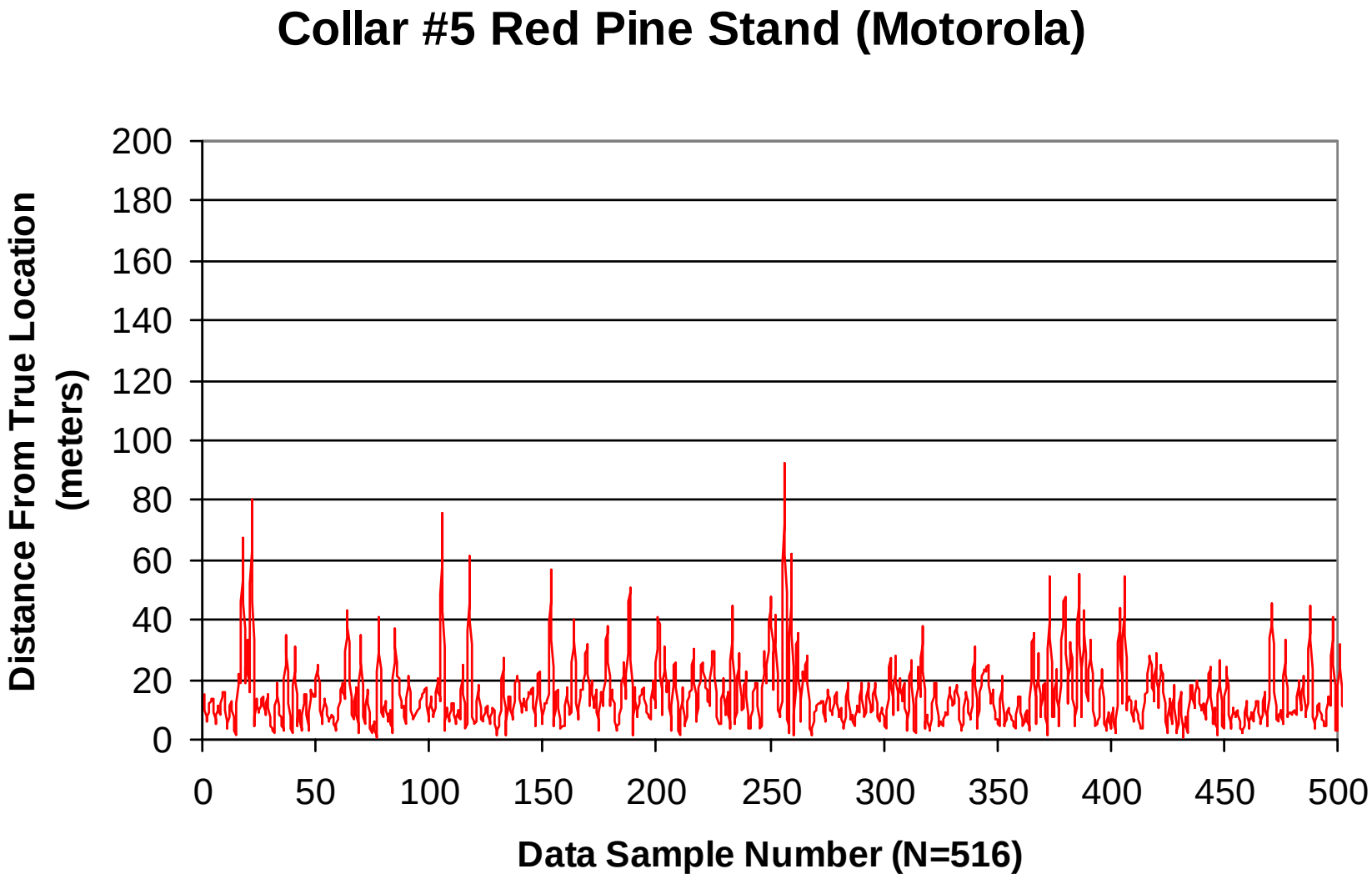


The next four graphs show the frequency and extent of the error excursions for the different receivers. Note that the scales on the Y-axis are not the same on all graphs.

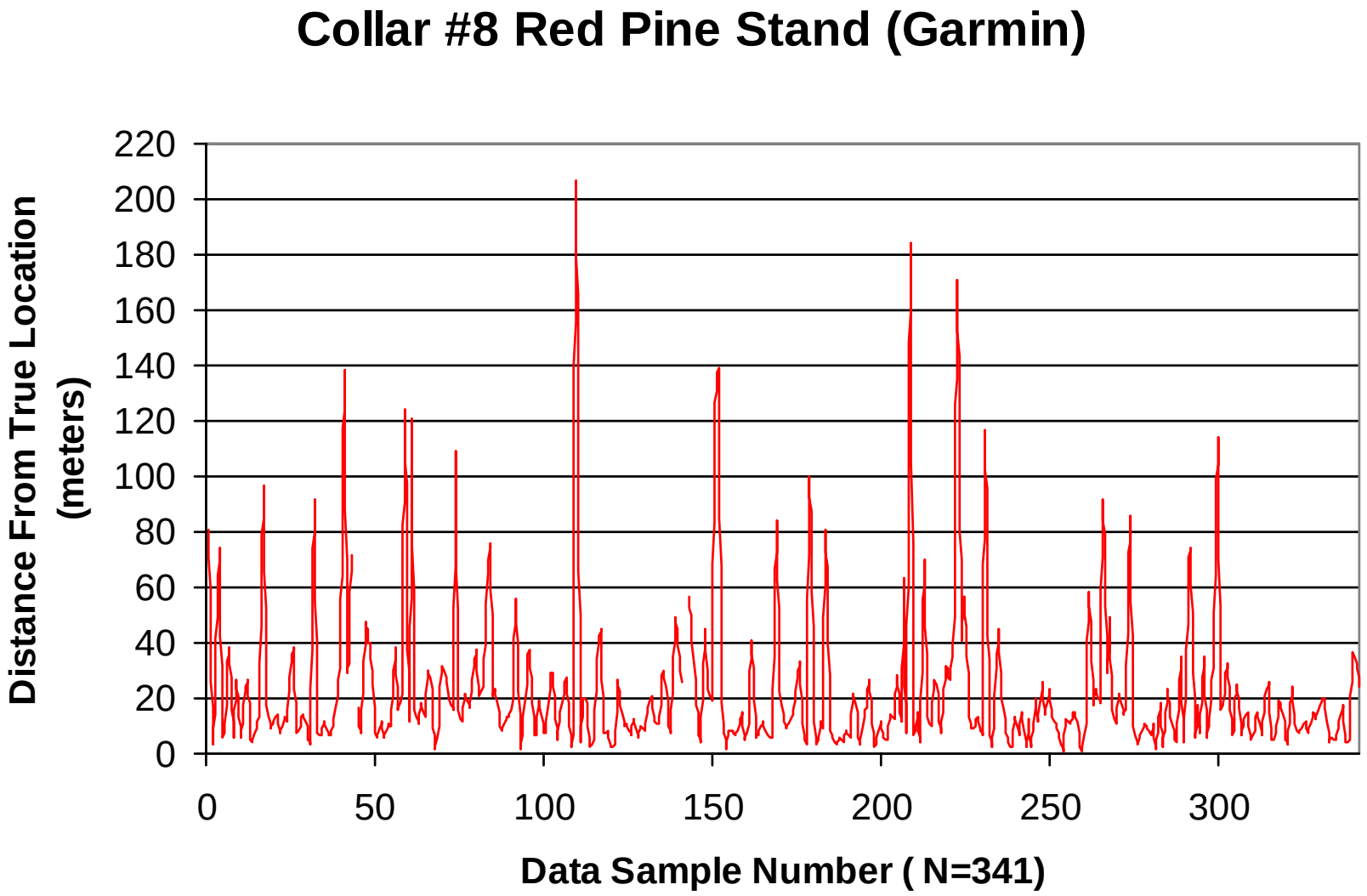
Error Excursions - Axiom



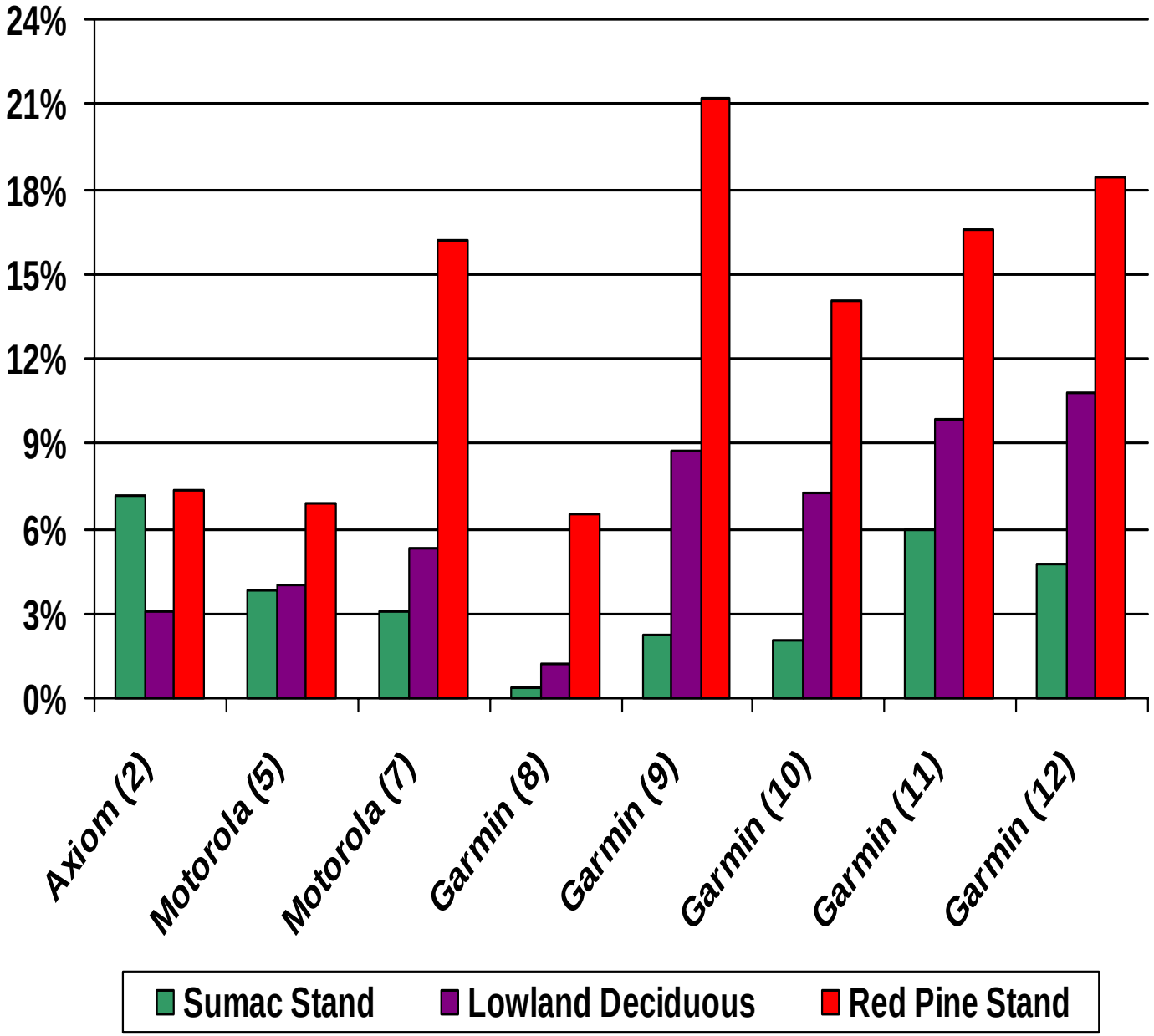
Error Excursions - Motorola



Error Excursions - Garmin



Percent of Missed Fixes



Percent of missed fixes, a possible indicator of marginal signals, is shown here. Mean errors for the Axiom and Motorola receivers were not significantly different from each other ($P<0.05$). All the Garmin receivers were also not significantly different from each other ($P<0.05$). However, the mean error of the Axiom and Motorola receivers was significantly different from all the Garmin receivers.

Discussion and Conclusions

The results of our study show that canopy cover can significantly affect the position error associated with an animal borne GPS system. Under ideal open-sky conditions, now that SA has been turned off, one can achieve the 15 meter RMS (1s) system accuracy specification. With increased foliage cover the signal received by the GPS receiver is degraded due to the loss of signal strength and multi-path signals. Under these conditions the receiver is not able to compute its location as accurately. The type of vegetation and tree cover determine the level of error that is to be expected. Larger tree diameters appears to be the more detrimental to position accuracy than basal area. We have also seen that some GPS receivers are better able to cope with degraded signals and are able to compute more accurate positions under dense cover.

The position errors introduced by heavily forested areas are large enough that performing differential correction would not be practical. Under ideal open sky conditions a position accuracy of 5 meters RMS is possible using differential correction. Under heavy tree cover, the position error (without differential correction) can be an order of magnitude higher than this. Differential correction, whether it be in real time or post-processed, could not correct the errors introduced by this type of environment.

In determining if GPS technology is practical for a particular study one must consider the type of canopy cover expected. One cannot assume that the position accuracy quoted under ideal conditions will be met in all environments. Thus, while GPS technology is ideal for large-scale animal movements it is not necessarily practical for studies where utilization of fragmented habitats is needed within densely forested regions.